Introduction to *Mathematica*® with Applications

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To my wife Viorica, always with love

Foreword

The book (written by Professor Marian Mureşan) is intended to present the *Mathematica* system in a manner in which the reader will find it easy to acquire a part of the considerable number of mathematical instruments offered by the producer, based on a large variety of examples taken from different scientific branches.

The importance of the symbolic calculus is incontestable, since nowadays the scientific calculus is not reduced to the numerical one. Modern mathematical problems, or those appearing through modeling natural phenomena, lead to such complicated symbolic expressions that we need the help of computers to process them. The fast development of the computers' technical capacity has enabled the genesis of a new domain—the symbolic (or formal) calculus—through which a genuine human–machine collaboration is achieved. The symbolic calculus systems are aimed at automating difficult calculi. They provide simple access to many sophisticated mathematical instruments, using a simple yet flexible language, that allows avoidance of writing interminable subroutines (similarly to how it happens with utilizing traditional languages).

It is mainly mathematical aspects that are covered in this book, so that the reader can understand as precisely as possible how to handle the problem. At the same time, the user is warned with regard to the type of problems which can be solved by means of the computer and the necessity of the analysis and verification of the results. Special emphasis is given to the fact that a session of *Mathematica* is typically interactive. Often there are multiple ways to approach problems, the choice of one of them being made on the spot, according to the answer of the system. The reader is carefully guided to the most suitable choice.

The book contains 11 chapters on specific aspects of the *Mathematica* language or branches of mathematics in general, such as ordinary differential equations, to which Chap. 7 is dedicated. It is worth mentioning that part of the applications presented in the book have been elaborated by the author in recent years, being the subject of certain scientific articles mentioned in the bibliography. In this book, standard linguistic constructions are used.

The book is at an incredibly high scientific level, and it is useful to many categories of users; for researchers, professors, and students in scientific fields, the knowledge of such a symbolic calculus system is nowadays indispensable. Mathematics researchers can use the programs for testing some conjectures or even for proving some results that need a big amount of calculation (in differential geometry, number theory, combinatorics, theory of functions of complex variable, numeric calculus, differential equations). The book is useful for engineers, economists, and IT specialists, who can therefore benefit from easy access to a volume of vast mathematical knowledge. I would mention that parts of the content of this book have been presented during the scientific seminars held at the Faculty of Mathematics and Computer Science, having been highly appreciated. Thanks to all of the above mentioned, I strongly recommend Prof. Marian Mureşan's book.

Cluj-Napoca, Romania Prof. Valeriu Anisiu
August 2016

Preface

This book is the output of our work over several years. Being involved in calculus of variations and optimal control problems, we have realized that an exact calculation and a suggestive visualization are very useful, making the ideas addressed many times only in an ε-δ language clearer. Then we have chosen *Mathematica* for computations and visualizations of the ideas. Why did our option go to *Mathematica*? The answer is simple: because we had noticed the wonderful results of Prof. J. Borwein and his colleagues regarding the decimals of number π. Their approach was based on an extensive use of *Mathematica*.

Wolfram Research, located at Champaign, IL, USA, is the company which has been developing *Mathematica*.

Mathematica is continuously developing. We used *Mathematica* 10.3. It is very likely there will be newer versions with extra facilities in the future.

We have introduced notions and results in *Mathematica* in our lectures to master students at the Faculty of Mathematics and Computer Science of the Babeş-Bolyai University in Cluj-Napoca, Romania. We did the same thing with our PhD students at three summer schools organized in the framework of the grant "Center of Excellence for Applications of Mathematics" supported by DAAD, Germany. The summer schools have been organized in Struga (Macedonia, FYROM), Sarajevo (Bosnia and Herzegovina), and Cluj-Napoca (Romania).

This book is not very large, but it collects many examples. In the first part of the book, the examples are discussed in detail helping the reader to understand the reasoning in and with *Mathematica*. Later on, the reader is led to use the benefit of the Help and other sources freely offered by Wolfram Research. We take into account mainly the Wolfram community forum as well as the video training and conferences generously offered by Wolfram Research.

A well-motivated case for visualization in mathematics is contained in [58].

Here is the right place to express my gratitude to the following colleagues of mine from the Faculty of Mathematics and Computer Science of the Babeş-Bolyai University for their support: Anca Andreica, Valeriu Anisiu, Paul Blaga, Virginia

Niculescu, Adrian Petruşel, and Adrian Sterca. The existence and development of the MOS (Modeling, Optimization, and Simulation) Research Center of our faculty was a real help for us in the preparation of this book.

Cluj-Napoca, Romania Prof. Marian Mureşan
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